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MODELS OF PURPOSIVE HUMAN ORGANIZATION: A COMPARATIVE STUDY

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The authors have previously presented a framework for a generic model of purposive human organization, based on relationships between pairs of resources, pairs of tasks, and resource-task pairs. This study compares the relational model, on the bases of conceptual foundations, function, and operation, with the socio-technical model. In addition to the theoretical comparison, a detailed example of a hypothetical organization is presented.

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Foreword

This study was conducted for the U. S. Army Research Institute for the Behavioral and Social Sciences, 5001 Eisenhower Avenue, Alexandria, Virginia, under Contract #MDA-903-81-M4220, dated 1 April 1981. Contracting Officer's Representative was John R. Mietus, Ph.D., Leadership and Management Technical Area, ARI. The research was done at the School of Architecture, University of Illinois, Urbana-Champaign.

It is the second in a projected series of studies addressing the development of a comprehensive organization modeling tool, to be used in organization design and analysis. Interested readers may obtain more information about the research program and its publications by contacting

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Models of Purposive Human Organization:

A Comparative Study

FINAL REPORT

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Models of Purposive Human Organization: A Comparative Study

1. Summary

There is a growing awareness that a holistic, systems approach must be taken if the Army is to maintain a high level of combat readiness, an approach dependent upon the development of maps and models to show the interrelationships between the various human components in the Army, and how they come together to be an effective fighting force. Specifically needed are integrated force composition and force effectiveness models.

Analytic organization models taking a holistic perspective do not exist at the level of development required to support the Army's needs, but work is proceeding in several areas to develop comprehensive organization modeling tools.

This study was undertaken to examine and compare, on the bases of conceptual foundations, function, structure, and operation, two organizational models, the structural model described by Dinnat and Murphree (the D-M model)[1,2] and the socio-technical (S-T) model described by Pasmore, et al.[3,4]

While the models are compatible and complementary, their intended functions are different. The D-M model allows the detailed documentation and examination of the internal structure and functioning of an organization. The S-T model is conceptual, not structural, and guides the diagnosis and intervention in malfunctioning organizations.

There is no conceptual antagonism between the two models. It appears that to a certain extent each can be expressed in terms of the other. This is not to say, however, that they are identical, nor even equivalent. Each can contribute to the development of the other; *together, they hold the promise of providing* exactly the analytic tools needed by the Army.

Specific recommendations are to adapt S-T interview techniques to gather data for the D-M model; and to develop techniques for organizational diagnosis with the D-M model, to be followed by intervention by S-T methodology.

2. Introduction

2.1. Background

In a recent study on human issues, the Army Science Board stated that there is "a growing recognition that a holistic approach must be taken if the Army is to compete successfully in the manpower market place and maintain a high level of combat readiness that can be translated into successful combat effectiveness."[5] This same study calls for the development of maps and models (terms which are equivalent to static and dynamic formal representations) to show the interrelationships between various human components in the Army to aid in "reviewing existing research, in identifying present and forecasted trends, in planning the future research agenda, and in developing the analytical capabilities and resources needed should forecast phenomena occur."[6] Specifically mentioned is the need for integrated force composition and force effectiveness models.

There is, then, a growing awareness on the part of Army planners that adequate holistic organization modeling tools do not exist; and, that there is a clear and immediate requirement for such models.

2.2. Purpose of the Study

This study was undertaken to characterize, in compatible terminology, two organization models, the structural model described by Dinnat and Murphree, [1,2] and the socio-technical model described by Pasmore, et al.[3,4] The models were compared to each other on the bases of conceptual foundations; function, or the purposes each serves; structure, or the modes of representation for each model; and operation, or how each is used to accomplish its purposes.

2.3. Organization of the Report

A brief introduction to modeling and the role of models in management is presented, followed by an analysis of each of the two models. Each analysis follows the pattern introduced above, i.e., Conceptual Foundations, Functions, Structure, and Operation. The two models are then compared, again with the same pattern guiding the comparisons. An extensive example, selected from socio-technical literature,[3] is presented using D-M notation and format, as a means of demonstrating the compatibility of the two approaches to organization modeling. Conclusions and Recommendations conclude the report proper. References noted in the text are listed as an Appendix to the Report.

3. The Models

3.1. Models and Their Role in Management

In general usage, a model is a representation of selected aspects of reality. Thus, a model ship represents, to a smaller scale, the physical shape of the full-scale counterpart. Abstract or conceptual models allow us to form conclusions about probable consequences of observed events. For example, a simple cause and effect model might prompt one, upon seeing dark clouds and feeling a damp, chill wind, to predict rain. Modern engineering is dependent upon analytical models, those which employ mathematical representations of physical behavior to predict performance of, say, bridges and buildings under load. Since the early 1940's, much progress has been made in representing the structure and behavior of operational systems in terms of mathematical models. Computers make very large mathematical models practical. The trend is toward larger, more comprehensive models, toward truly holistic representations of very large operational systems. The emphasis has been concentrated on modeling processes; little attention has been focussed on the processor, i.e., the purposive organization, which is the subject of this study.

Mathematical models (herein after, simply models) are of two basic types, static and dynamic. The Army calls static models maps, and they are essentially a graphic display, often with boxes and arrows, of how people, equipment, etc., come together to achieve some purpose. Maps are a snapshot, a slice in time, of how a system works.

A dynamic model (model, in the Army's terminology) is more than a map, although a map may, and often does, form the basis for the model,

in that it represents not only the structure of a system, but also its *functioning* in time. A model can be used to study the interaction of system components over time and to make conclusions about how the real system might perform.

The user of a model must make two important abstractions. First, he must adapt a model to represent the real system of interest and verify that the representation is accurate. After exercising the model, he must then interpret the results in terms of the probable behavior of the real system. A naive user can relate directly to the behavior of the model, and fail to make an appropriate transfer back to reality.

Despite the conceptual contortions often necessary to go from reality to model and back to reality, use of mathematical models can be highly beneficial to the manager of human resources. In the following sections, we examine the characteristics of two different models, models which differ materially in form and function, but which are shown to be both compatible and complementary.

3.2. The Dinnat-Murphree Model

3.2.1. Conceptual Foundations

The Dinnat Murphree Model (D-M model, hereafter) is based on the premise that human organization is the product of the relationships between pairs of resources and tasks, the basic objects of the D-M model. Each relationship (e.g., "is superior to," "is on team X with," "carpools to work with," "provides information for," "must be completed before," "is assigned responsibility for") between pairs of elementary (indivisible) objects potentially creates a new object, i.e., a compound object. Examples of compound objects are: divisions, sections, committees, teams,

brigades, companies, and squads as combinations of resources; and functions, jobs, and projects as combinations of tasks. And, of course, compound objects may be combined (through appropriate relationships) into new compound objects, of even greater complexity.

These simple mechanisms allow us to construct comprehensive representations of authority hierarchies, information flows, group membership, work assignments, and all the other elements of human organization. Resource-resource relationships map internal social structure, including both formal and informal relationships. Resource-task relationships show assignment of resources (e.g., personnel, equipment, space) to tasks. Task-task relationships show information or product flow, task precedence, and task decomposition into sub-tasks.

3.2.2. Functions

The D-M model was conceived in response to a need for an objective means to represent the observed structural characteristics of human organizations, beyond the simplistic, and often misleading, "wiring" diagrams showing authority relationships and functional groupings. The notation is intended to guide the organization designer in specifying <u>all</u> the critical relationships, functional groupings, information and material flows, etc., that a viable organization must possess to survive. The intent has been to minimize the ad hoc linkages that accumulate within an inadequately specified organization as it attempts spontaneously to adapt and survive. The primary aim has, then, been at <u>organization design</u>.

Fundamental to the operational success of an enterprise is the accomplishment of work. The model has been designed with <u>operations</u>

planning and control in mind, specifically as an aid in task analysis and synthesis and the assignment of resources to tasks.

For the existing organization, the model is designed to assist in dysfunction diagnosis, and, through use of the dynamic (time-dependent) exercise of the model in parametric (i.e., "what if") studies, to act as guidance for intervention.

3.2.3. Structure

The D-M model is based on diadic relations between pairs of resources, pairs of tasks, and resource-task pa The state matrix lends itself easily to representing these relationships, as in Figure 3.1.

With specific resources and tasks itemized on the diagonal, direct representation of pair-wise relationships is possible by appropriate notations (here a dot) in the off-diagonal elements. Each element a_{ij} is, in fact, a vector, each element of which represents a different relationship between object (row) i and object (column) j. The model becomes, then, a 3-dimensional solid, each "layer" of which is a 2-dimensional matrix displaying the relationship patterns of a distinct relationship category.

Figure 3.2 shows a traditional organization chart of a hypothetical organization. Figure 3.3 shows the matrix representation of this same organization.

The objects represented by the diagonal matrix elements are the human and material resources and the elementary tasks which the organization is capable of performing; and, the groupings of these resources and tasks into more complex entities, e.g., committees,

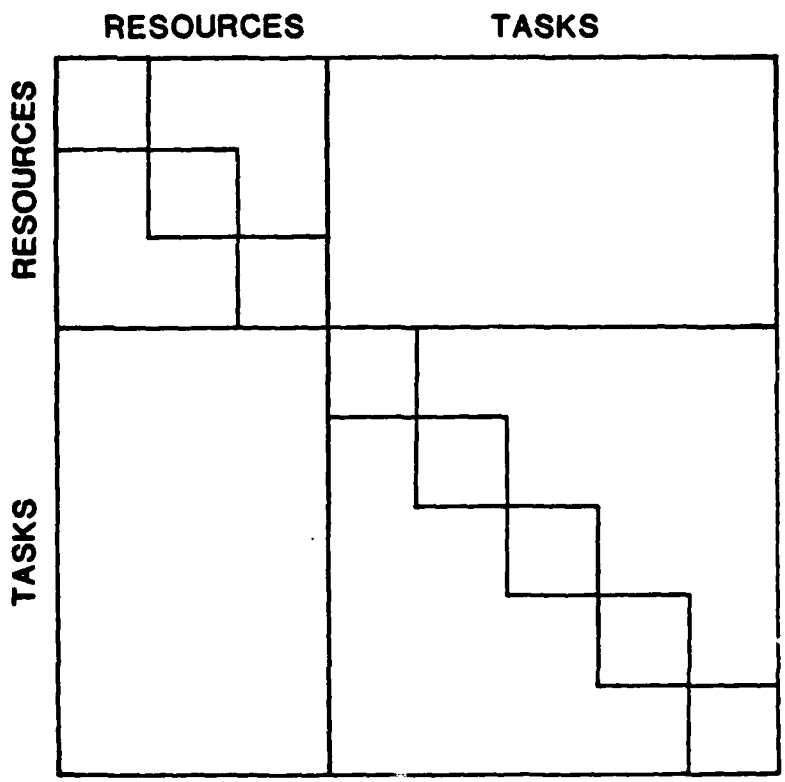

FIGURE 3.1. STATE MATRIX

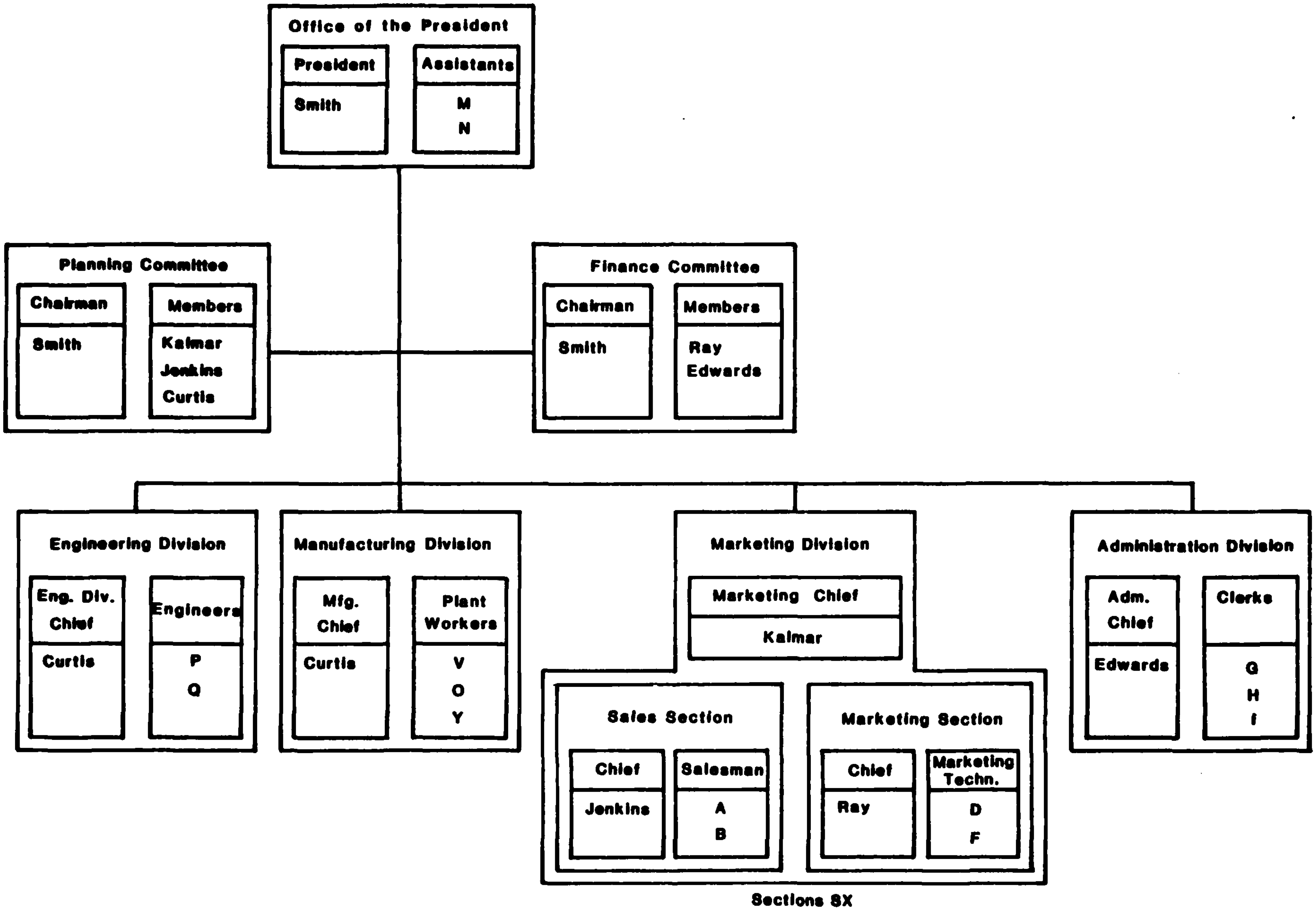

FIGURE 3.2. TRADITIONAL ORGANIZATION CHART

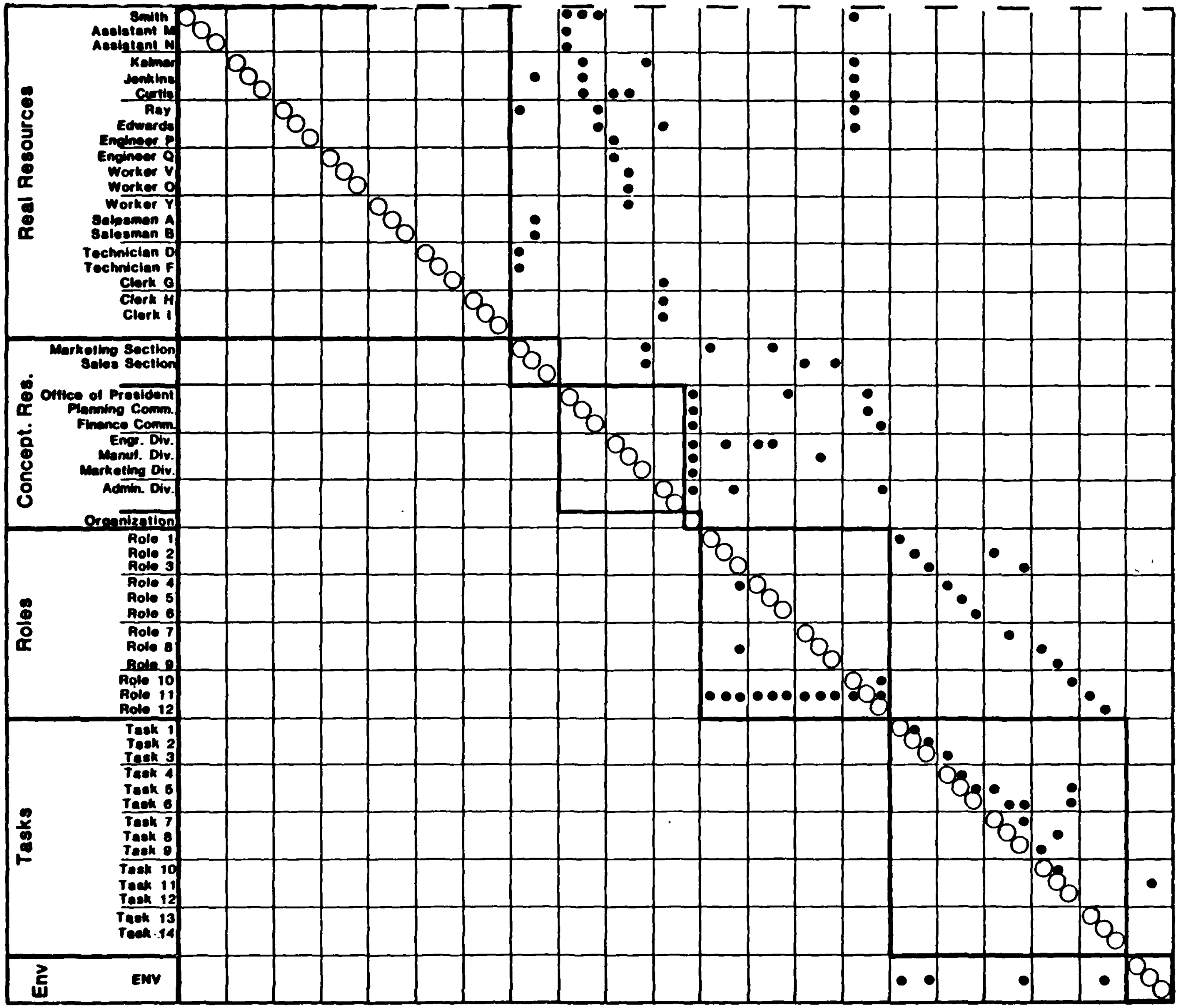

FIGURE 2.2 MATRIX REPRESENTATION OF THE EXAMPLE ORGANIZATION

sections, task groups; and projects and jobs. Every identified such entity has a position on the matrix diagonal. It is convenient to subdivide the general classes of resources and tasks into, as shown in Figure 3.3, Real Resources, which include persons, equipment, spaces, and the like; Conceptual Resources, which include groupings of Real Resources; Roles, which identify sets of skills which are useful in assigning work responsibilities; Tasks; and, in some cases, the Environment. Each of these objects is represented by a circle on the matrix diagonal, with further identification shown to the left of the matrix proper.

The real resources of Figure 3.3 are persons and each is assigned to one or more conceptual resources, organizational groupings. Smith, for example, is assigned to the Office of the President, the Planning Committee, and the Finance Committee, as shown by dots in the appropriate rows and columns. The Office of the President performs Role 6 and Role 11, which are in turn assigned Task 6 and Task 13, respectively, as shown in Figure 3.3.

Again by examining the pattern of dots in Figure 3.3, we note that the flow of precedence (information, material, etc.) is from Task 5 to Task 6, Task 7, and Task 12; while Task 12 is preceded by both Task 5 and Task 6. The Environment (ENV) provides input to Tasks 1, 3, 9, and 14, while receiving input from Task 11.

From a single matrix, then, we can learn a great deal about the resources of an organization, its internal structure, the roles played, and the ordering of the tasks it performs, all by the single construct of the diadic relationship, applied in a variety of ways.

3.2.4. Operation

In use, the D-M model must be particularized for an existing or hypothetical organization by (1) preparing a blank matrix with the resources and tasks, at all levels of detail of interest; and, (2) representing every diadic relationship of interest in the prepared matrix. The model is capable of handling resource and task definitions at any level, from Federal Agency-size down to a few workers in a small office, with task representation appropriate to the situation under scrutiny.

Relational patterns, i.e., the sets of relationships of specific types, such as skills related to role assignments, or tasks assigned to a single individual, or the number of tasks dependent upon input from a single task, or the tasks that are dependent upon input from many tasks, or the number of tasks controlled by a single person, and so on, form the roots of "understanding" an organization, its strengths, vulnerabilities, and pathologies. These relational patterns become detectable only after the hard work of model preparation has been done, either analytically in the case of an existing organization, or synthetically in the hypothetical case. The study of Figure 3.3 will reveal many patterns.

Detection and documentation of relational patterns related to organizational pathologies or anticipated dysfunctions set the stage for organization modification, through the means of relational changes: regrouping of personnel; change of equipment, space, task assignment; alteration of task precedence, with attendent information and material flow changes; task redefinition, procedural change. Every change can be explicitly recorded in the matrix.

It is not within the capability or intent of the present model to predict organization behavior, given its relational structure. It is, however, within the intent of the developing model to simulate ranges of behavior, to detect impossibilities of performance, and to allow the organization designer to revise the structures from which the anomalies arise, and to close the gap between can and cannot.

The fully-developed modeling technique will support pencil-and-paper diagnostics with a purely descriptive approach to organizational performance; through extensive, detailed planning of hypothetical organizations; to computer storage and retrieval of relational data and pattern detection; and full-scale computer simulation of organization behavior under varying external and internal conditions.

The reader is reminded, however, that the model is in many ways like the bars and notes of sheet music; it does not attempt to control or interpret the score, nor to criticize the performance. It is a vocabulary, with syntax rules but limited semantic content, a <u>language</u> for modeling human organization.

3.3. The Socio-Technical Model

3.3.1. Conceptual Foundations

Socio-technical systems (S-T) theory holds that human organizations are composed of two separate, but interrelated, subsystems: the <u>social subsystem</u>, made up of the members of the organization and their relationships; and the <u>technical subsystem</u>, containing the tools, knowledge, and methods used by the members of the organization to perform tasks. The basic idea behind the application of S-T theory to intervention in organizations is that the operation of each subsystem depends upon the

structure of the other. The social subsystem cannot operate efficiently unless the technological subsystem is structured so as to enhance the relationship needs of organizational members; and the technical subsystem cannot operate efficiently without the cooperation of members of the social subsystem. When both subsystems are structured so as to produce the most effective overall organizational functioning, the S-T system is said to be "jointly optimized."

S-T systems approaches to organizational change are holistic or systemic, addressing every part of the organization as well as its environment; and they address directly the way in which tasks are performed.[3]

3.3.2. Functions

Socio-technical systems theory forms the foundation of an approach to organization change. The theory has evolved out of practice, and provides a means for assessing the general health of an organization and identifying areas of apparent dysfunction. It focuses primarily on the relationship between the organization member and his job, including the tasks, skills required to perform the tasks, and nearest other organization members (fellow workers, superiors, and those who report to the member).

Areas of dysfunction in the organization are identified and presented as candidates for change, through direct intervention at the worker-task level. S-T theory guides the intervenor in the global development of intervention tactics through the general proposition that the organization works best when <u>both</u> the social subsystem and the technical subsystem are mutually supportive.

In summary, then, S-T theory does not seek to formally model the structure of human organizations. Rather, it provides a general perspective of the organization as comprised of social and technical components; and a philosophical framework for diagnosing organizational ills and intervening to improve functioning, based on the proposition that both subsystems must be coordinated and "jointly optimized," and that the myopic concentration on one to the exclusion of the other will insure organizational mediocrity or failure.

3.3.3. Structure

The S-T model is conceptual rather than structural. Its elements are human resources and tasks, like the D-M model, and their interrelationships with one another. Sets of relationships are in certain configurations termed "boundaries," and form a basic tool in isolating malfunctioning organizational units. The model is broad in scope and covers actions and beliefs of individuals and groups from the task level through inter-organizational and societal relations.

3.3.4. Operation

The S-T approach to organization design or change is rooted in three general propositions:[3]

Proposition 1: People work better when:

A. They are provided with opportunities to satisfy their own needs and goals through the work itself, such as:

1. Feedback on performance
2. Recognition

3. Variety
4. Learning, increasing skills and knowledge
5. Ability to do important/complete work
6. Ability to relate product to consumer
7. Social relationships

B. They are allowed to be involved in making decisions which affect them.

Proposition 2: The Task gets done better when:

A. People are multi-skilled and responsive to change

B. Problems are solved at their source

Proposition 3: The organization works better when:

A. The relationship between the social and technical systems is optimized so that requirements (1) and (2) above are met

B. Organizational leadership, structure and policies are supportive of (1) and (2) above

C. Cooperation is maximized within and across levels of the organization

D. The organization is able to detect and respond to changes in its environment

The model is used as a guide to intervention in organizational dynamics. The interven~~o~~er uses both standard (e.g., the Job Diagnostic Survey, by Hackman and Oldham)[7] and organization-specific instruments to gather data on the social system; interviews are often used to flesh out the picture, and to provide clues to the organization's strengths and weaknesses.

Technological system analysis is based upon task analysis. The basic goals of this analysis are to identify problems or "variances"

that occur as a result of the way technology is operated, and determine who is responsible for controlling the "variances" and what information they need. These data are displayed in a variance matrix.

The details of organization intervention by techniques based upon S-T theory are outside the scope of this study, which confines itself to an analysis of the models themselves, rather than to action methodologies. The interested reader, however, will find a comprehensive treatment in Reference 3.

4. The Models Compared

4.1. Conceptual Foundations

Both models are based upon a concept of human organization as the totality of the relationships among human and other resources and the tasks to be done. While the D-M model builds a structural framework within which patterns of relationships can be displayed and examined, the S-T model concerns itself with going straight to the feelings, attitudes, movements, and beliefs of the individual worker. Implicit in the D-M approach is that the behavior of the organization is the result of the patterns of diadic relationships, while the S-T approach implies that the key to organizational behavior is individual behavior.

4.2. Functions

The D-M model allows one to document, display and examine the anatomy of an organization. The S-T model provides a perspective for the diagnosis of organizational dysfunction and a guide for intervening in the organization's workings, with an eye towards improvement.

4.3. Structure

The D-M model is highly structured: its structure is all-important. The S-T model is descriptive in form.

4.4. Operation

The D-M model is descriptive of the organs and structures and functions which comprise the organization; the S-T model is a springboard for action.

4.5. Summary

The D-M model details what an organization is and how it works; it provides the tools for an intricate detailing of the "machinery" of human organization. The S-T model guides the practitioner.

5. An Example

5.1. Introduction

The foregoing has been a theoretical comparison of the socio-technical approach and the Dinnat-Murphree model. It is useful now to look at how the D-M model might be used in an analysis of a hypothetical organization, using the S-T approach as a guide. Emery and Trist have suggested a step-by-step approach to gathering and organizing data from a target organization,[8] which appears below. Pasmore, et al. have presented an example featuring a hypothetical automobile repair facility.[3] We have elaborated on this example in order to demonstrate application of the D-M model. In the next section, the steps are generally followed, but some liberties have been taken with the actual content of some steps. The example is meant to be an illustration, and not an exhaustive analysis.

5.2. The Steps in Sociotechnical Intervention[8]

Step 1. Initial Scanning

Step 2. Identification of Unit Operations

Step 3. Identification of Key Process Variances and Their Interrelationships

Step 4. Analysis of the Social System

Step 5. People's Perceptions of Their Roles

Step 6. Maintenance System

Step 7. Supply and User Systems

Step 8. Work Environment and Development Plans

Step 9. Proposals for Change

5.3. Initial Scanning

The objectives of this step are to identify the main aspects of the production system and the main groupings of the organizational structure. It should cover the following areas:

a. the objectives of the system

b. the main inputs and outputs of the system

c. the main transforming processes that take place within the system

d. the main groupings of the organizational structure

The main objective of the car repair shop is to produce repaired cars.

In Figure 5.1, the main inputs (cars needing repairs, spare parts), the main transforming process (repair cars), and the main outputs (repaired cars) are identified and shown diagrammatically.

In Figure 5.2, the main groupings of the organizational structure are shown: the Dealership; Service Division, including the Shop and the

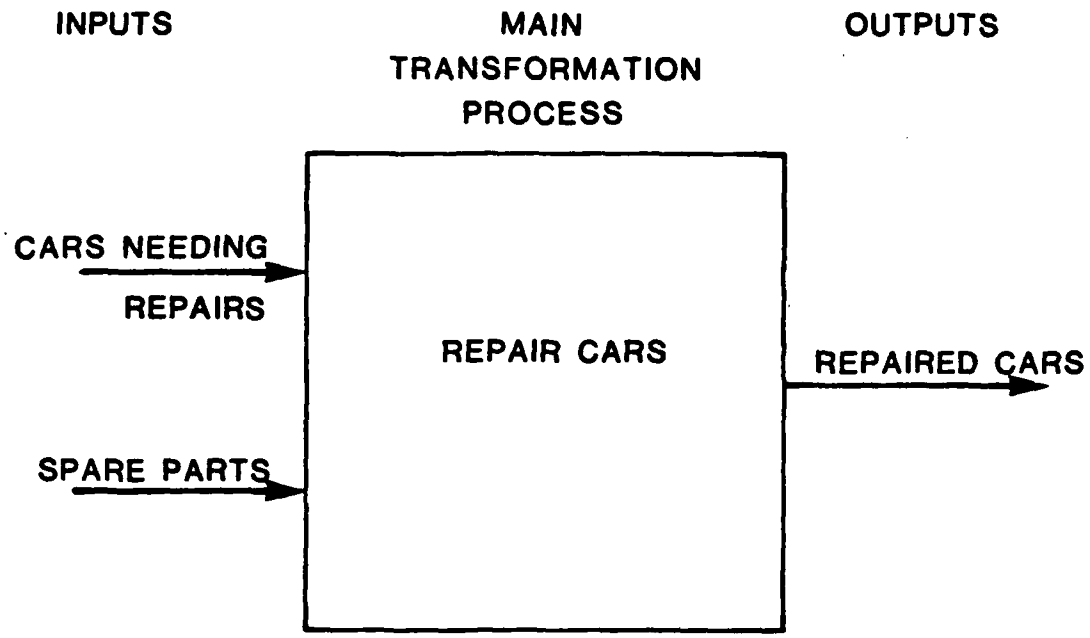

FIGURE 5.1. INPUTS, OUTPUTS, AND MAIN TRANSFORMATION PROCESS OF THE SYSTEM

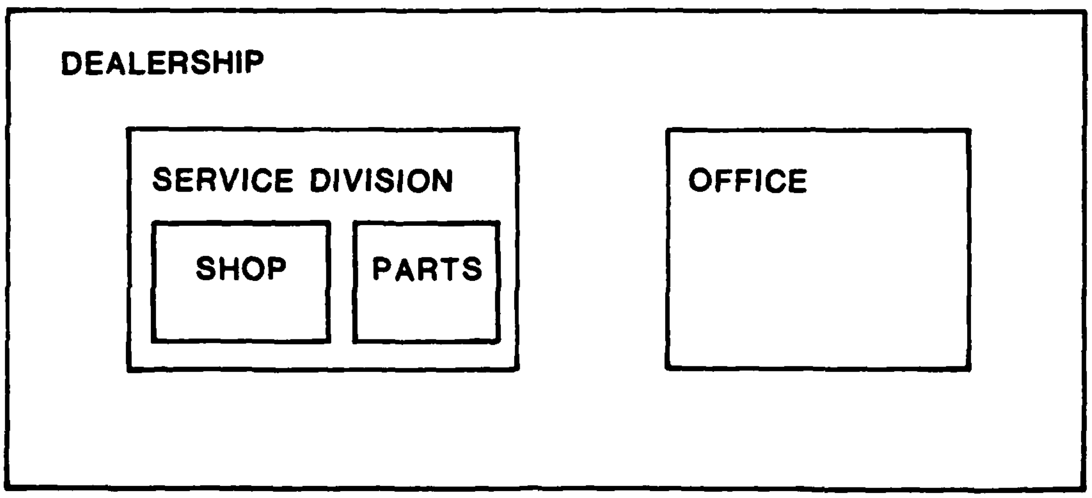

FIGURE 5.2. MAIN GROUPINGS OF THE ORGANIZATIONAL STRUCTURE

Parts Room; and the Office. The shaded portion of Figure 5.3 identifies these groupings (Conceptual Resources) and shows the structural relationships to each other that are implied in Figure 5.2. That is, the Dealership contains the Service Division and the Office, and the Service Division contains the Shop and the Parts Room.

5.4. Identification of Unit Operations

The objective of this step is to identify the main tasks or functions that are normally performed in transforming the input to output. These are the primary operational functions or tasks that the (purposive) organization exists to perform. According to S-T theory, each unit operation is relatively self-contained, and each effects an identifiable transformation on the products passing from raw material to finished products. Such a transformation can be a change in the physical state, a change of location, or storage of the material or product. A little imagination can extend these concepts easily to service and information handling situations.

We are not, at this stage, concerned with the resources (humans, machines, finances, time, etc.) required to effect the transformations --- only with the identification of each transformation in terms of its inputs, transformations, and outputs.

Figure 5.4 shows, in the shaded area, the main tasks, at two levels: the Conceptual Tasks are at the highest level of aggregation, categorizing tasks into Dealership Tasks, Service Tasks, Shop Tasks, etc. Tasks itemizes the basic steps through which the typical car-to-be-repaired passes, and are a "finer mesh" look at the Conceptual Tasks. Thus, several tasks constitute a conceptual task. Figure 5.5 shows the

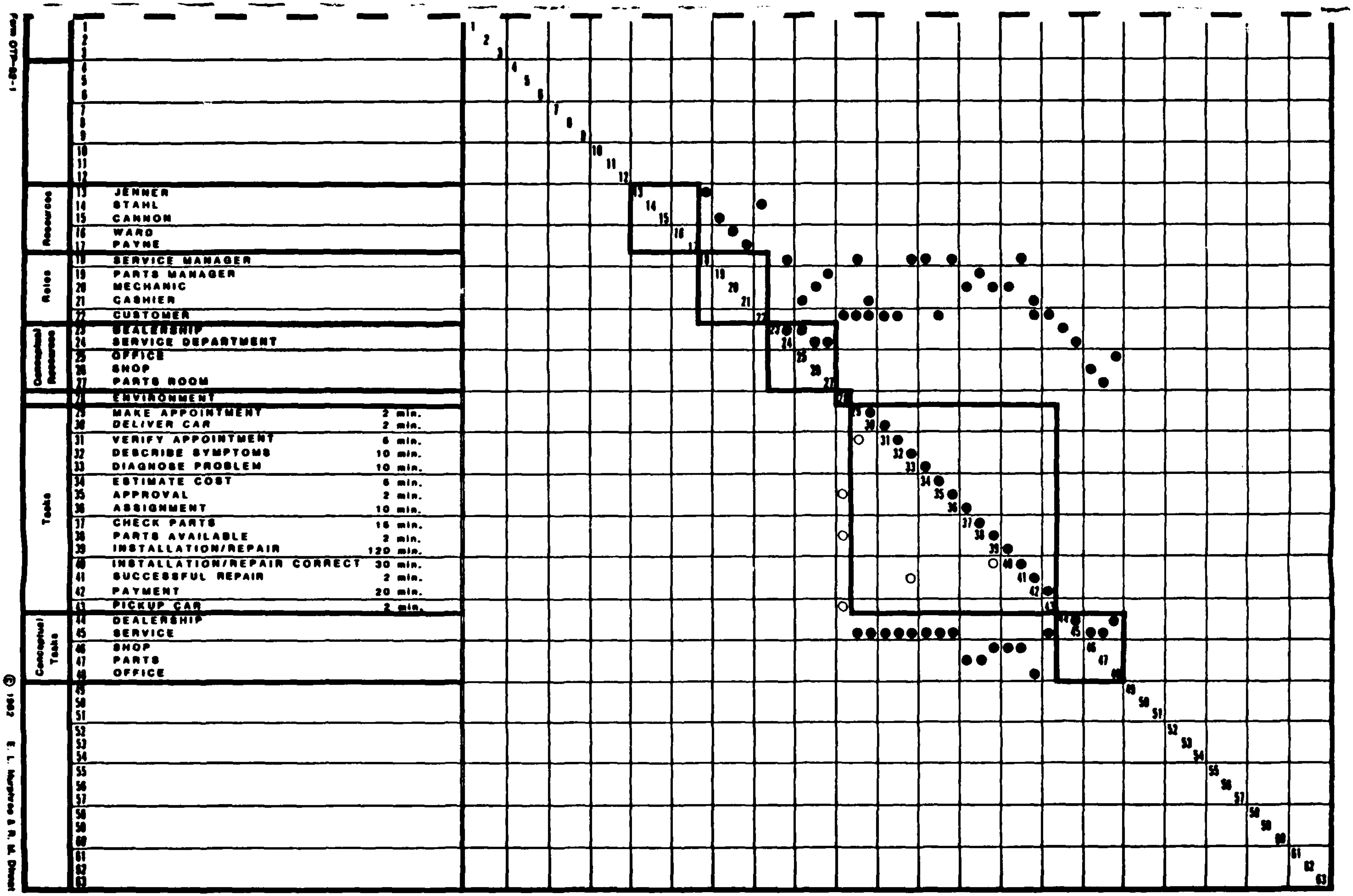

FIGURE 5.3. MATRIX REPRESENTATATION OF THE MAIN GROUPING OF THE ORGANIZATIONAL STRUCTURE

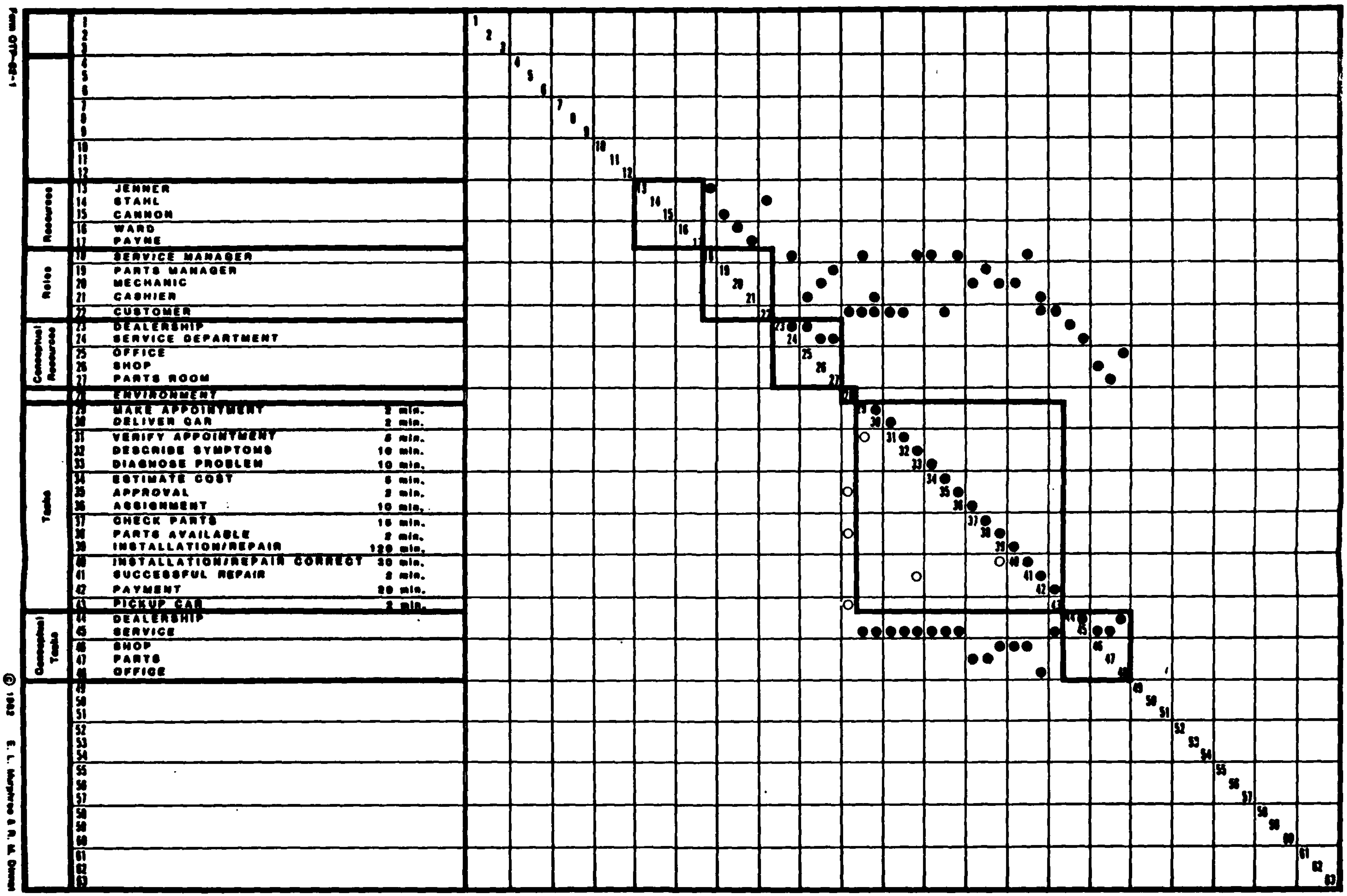

FIGURE 5.4. IDENTIFICATION OF MAIN TASKS

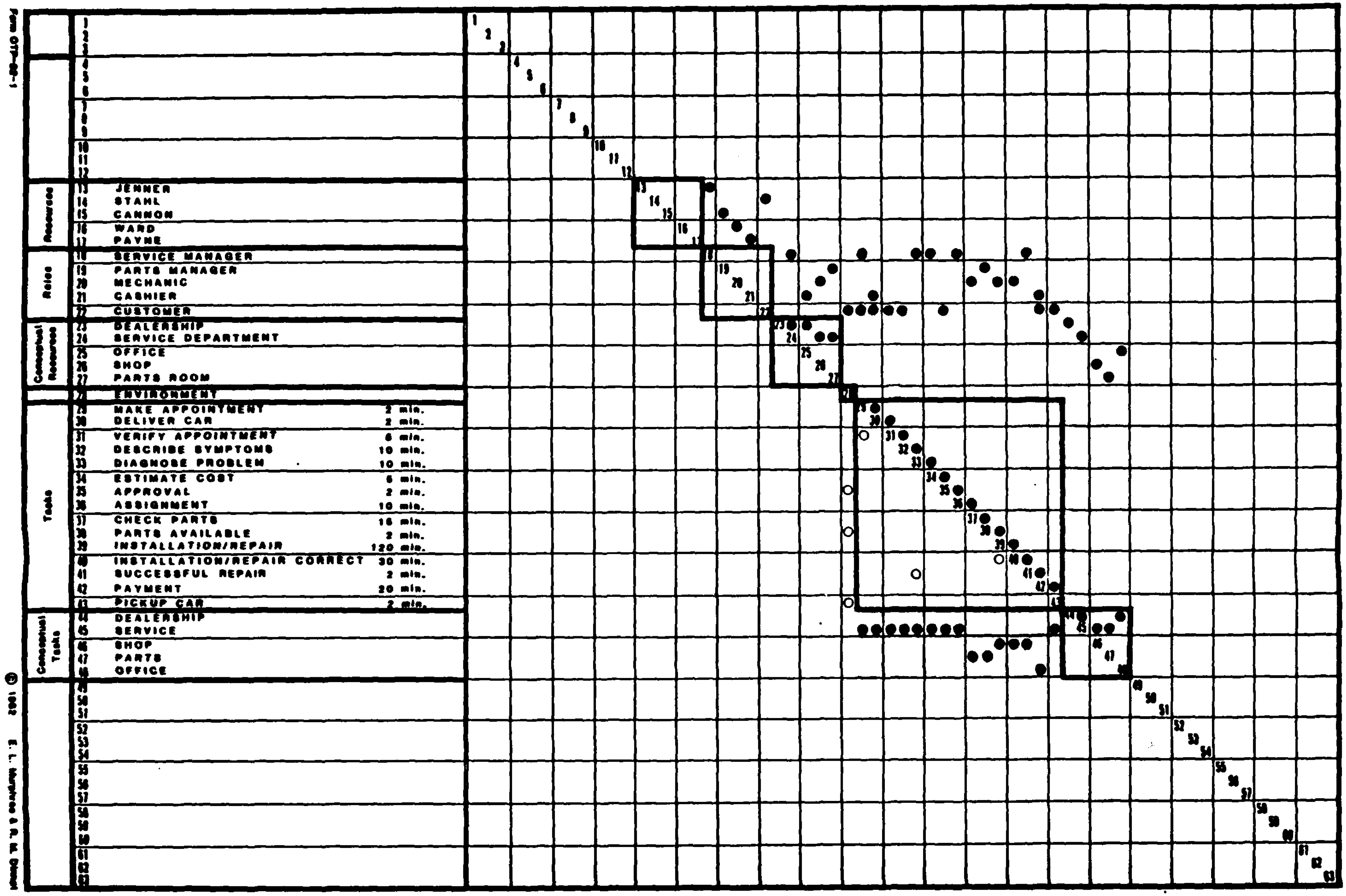

FIGURE 5.5. STRUCTURE OF MAIN TASKS

relationships of tasks to conceptual tasks. For example, the string of dots in the Service row (row 45) indicates that tasks 29 through 36 ("Make Appointment," "Deliver Car," -----, "Assignment") are all Service tasks. Every task is a part of a conceptual task.

Figure 5.6, in the shaded area, shows the inclusion-exclusion relationships of the Conceptual Tasks to one another. Here, we see that the Dealership Conceptual Tasks include Service and Office Conceptual Tasks; Service Conceptual Tasks include both Shop and Parts Conceptual Tasks.

Figure 5.7 shows, in the shaded area, the precedence relationships between pairs of tasks. This is, in effect, a representation of the flow of cars through the facility, but there is more information in the diagram than the flow of cars, as we shall shortly see. Figure 5.8 shows, in the shaded area, the assignment of Conceptual Resources to Conceptual Tasks. Thus, the Service Department is assigned, not surprisingly, Service Tasks to perform; the Parts Room, Parts Tasks; the Office, Office Tasks; and so on. Through Figure 5.5, of course, we know precisely which Tasks fall to the responsibility of each Conceptual Resource.

5.5. Identification of Key Variances

The objectives of this step are to identify the key process variances and their interrelationships. A variance is defined as a deviation from a standard. We are not concerned with all variances --- most variances do not materially affect the system's capability of meeting its overall objectives. We are concerned with identifying those variances that significantly affect the capability of the production system to pursue its objectives in one or more of its

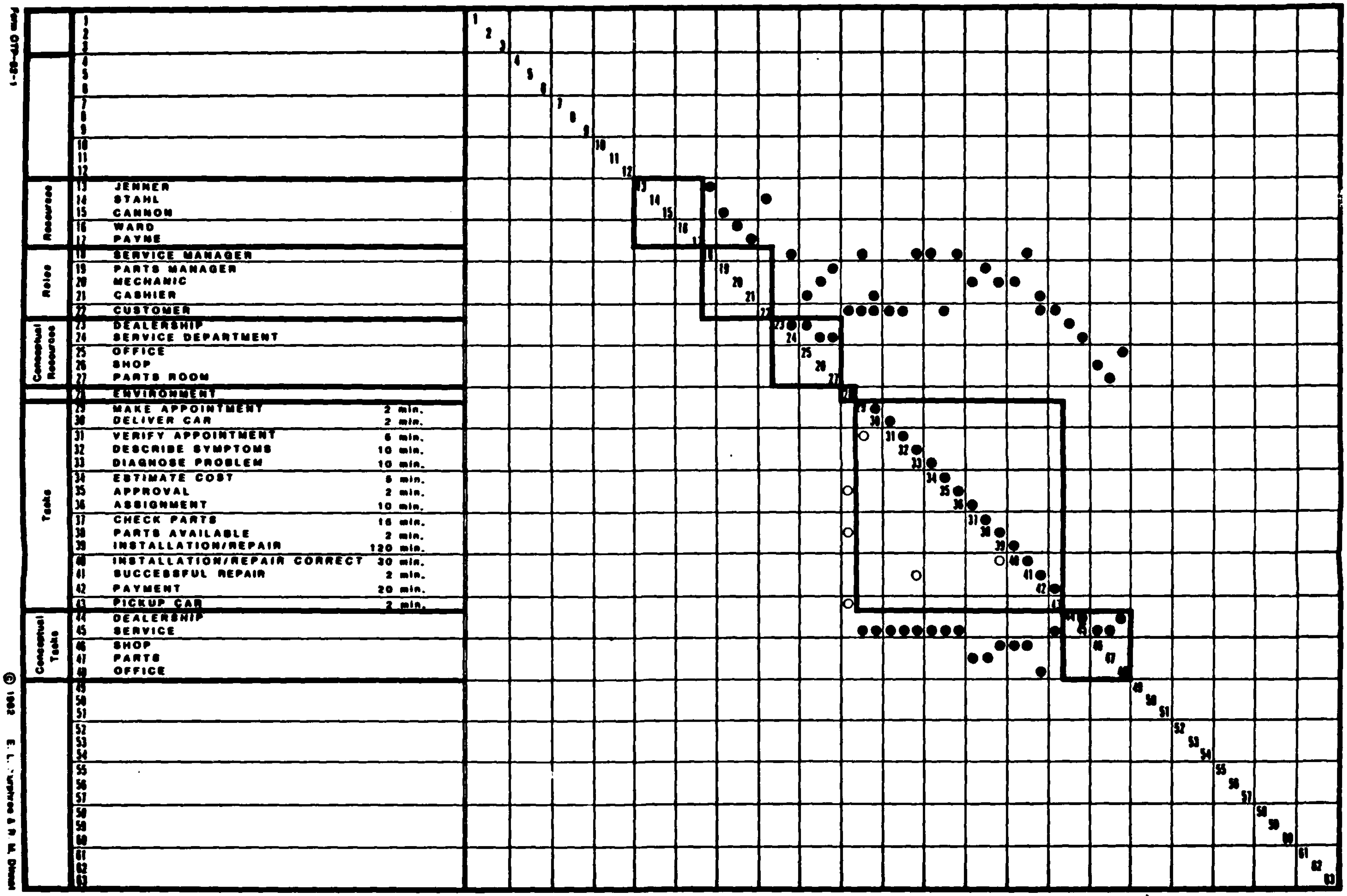

FIGURE 5.6. STRUCTURE OF THE CONCEPTUAL TASKS

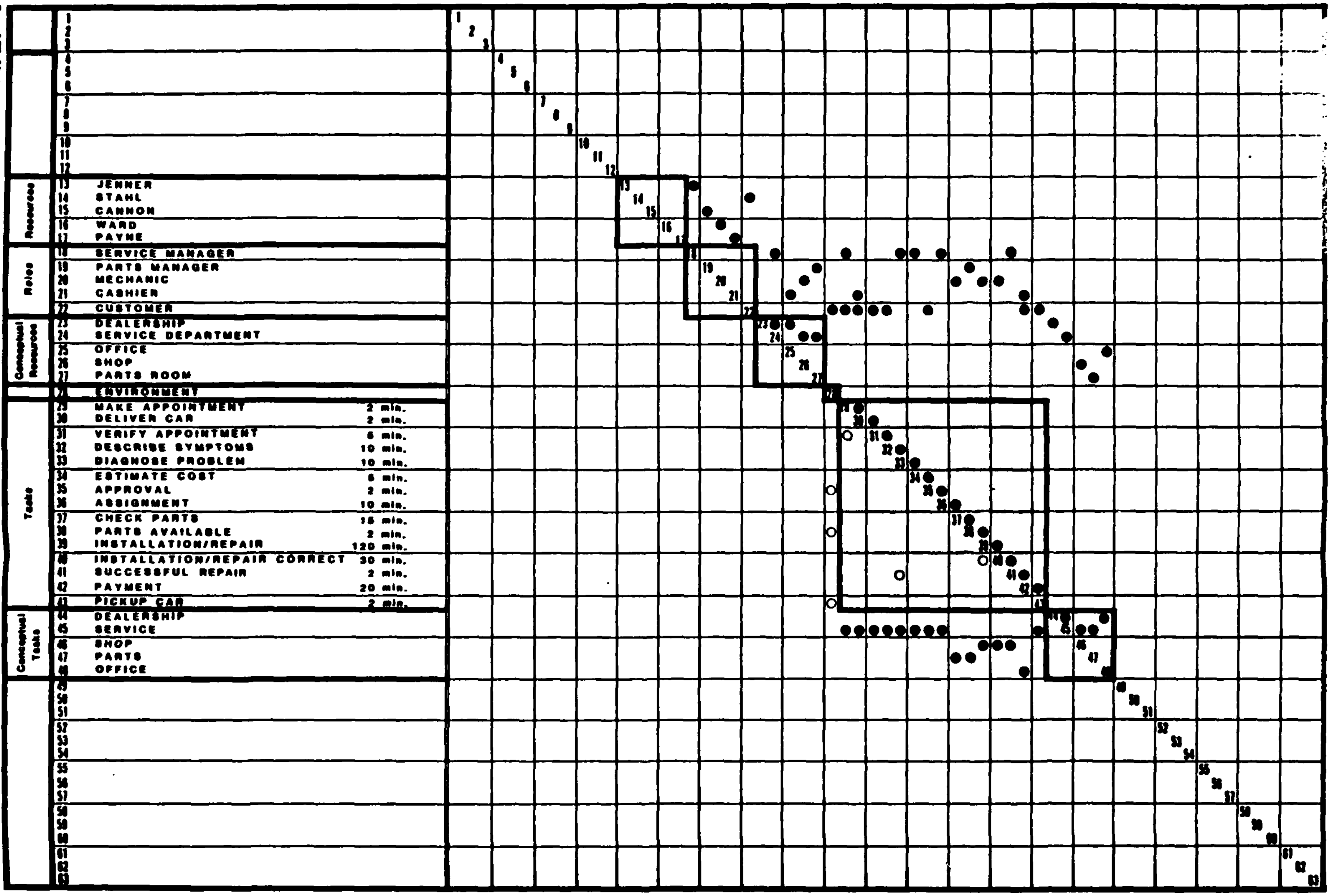

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FIGURE 5.7. TASK PRECEDENCE: FLOW OF CARS THROUGH THE FACILITY

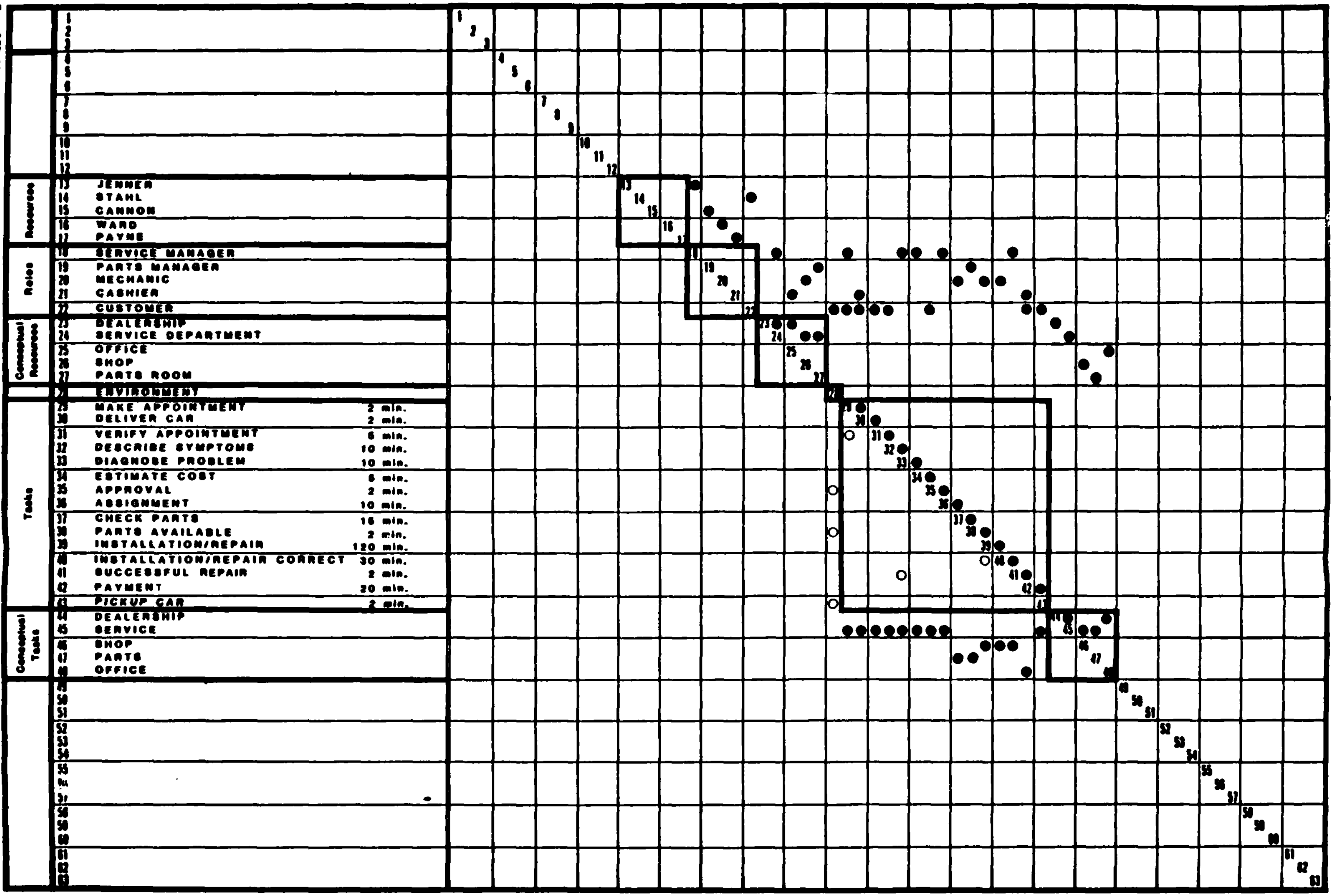

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FIGURE 5.8. ASSIGNMENT OF CONCEPTUAL RESOURCES TO CONCEPTUAL TASKS

functions (tasks), i.e., the <u>key</u> variances. One source of a key variance in the present example is the diagnosis function. If done incorrectly, the prime objective of the entire system, repairing the car, cannot be met. Socio-technical theory classifies a variance as <u>key</u>, if it materially affects:

a. the system's production objectives: quantity of production
   quality of production
   operating costs

b. the system's social objectives: social costs (stress, effort, hazard to the employees)

Socio-technical theory suggests that the <u>variances</u> be examined directly for level of impact on the system's production and social objectives, and be separated according to their relative impact on the system's objectives into <u>key</u> variances and other variances. The articulation of the variance potentials at each function or task (or, unit operation) is a valuable exercise for the intervening agent to perform. A variance matrix for the present example is shown in Figure 5.9.[3] Note that the diagonal of this matrix represents the <u>variances</u>, or erroneous results, that can occur at the unit operations (or functions or tasks), and not the operations themselves, as in the D-M model. Off-diagonal marks indicate a cascading effect of errors, <u>a propagation of errors through the system</u>. Thus, in column 3, corresponding to (line 3) "Customer describes problem incorrectly," we see marks in rows 4, "Estimate wrong"; 7, "Parts installed improperly"; and 8, "Repair ineffective." Clearly, if the "Customer describes problem incorrectly," the system's production objective, the successful repair of cars, will

PREPARATION	1.APPOINTMENT WRONG TIME	X								
	2.CAR TOWED TO WRONG LOCATION		X							
	3.CUSTOMER DESCRIBES PROBLEM INCORRECTLY			X						
	4.ESTIMATE WRONG			X	X					
	5.MECHANIC MISUNDERSTANDS INSTRUCTIONS					X				
REPAIR	6.PARTS UNAVAILABLE						X			
	7.PARTS INSTALLED IMPROPERLY			X		X		X		
	8.REPAIR INEFFECTIVE			X		X			X	
BILLING	9.AMOUNT OF BILL INCORRECT									X

FIGURE 5.9. VARIANCE MATRIX FROM THE SOCIO-TECHNICAL EXAMPLE

be adversely affected. Item 3 can be rightly identified as a key variance. It is important to note here the criterion for key variance: it is not that there were several marks in columns 3, but that there was a direct path from item 3 to item 8; item 8, "Repair ineffective," being the primary key variance directly affecting the system's production objective. With this criterion item 5, "Mechanic misunderstands instructions," also qualified as a key variance.

In emulating this valuable diagnostic procedure with the D-M model, we go *directly to* the tasks, and ask of every pair of tasks which are paired by a path of precedence relationships: "Does an error in the outcome of the predecessor task cause an error in the outcome of the successor task?" Figure 5.10 shows an enlargement of the Task-Task submatrix shown shaded in Figure 5.7. The dots represent precedences between pairs of tasks; precedences are read clockwise. A dot in column 14 of row 13, then, means that task 13, "Make appointment," is directly followed by task 14, "Deliver car (A)." Figure 5.11 shows the results of inquiring about the outcomes of tasks paired through a path of precedence relationships. *In this Figure*, task 14, "Successful Repair," is identified as the prime key task, corresponding to the prime key variance of Figure 5.9, "Repair ineffective." Marks in row 14 at columns 5, 6, and 9 identify "Describe symptoms," "Diagnose problem," and "Assignment," respectively, as key tasks, corresponding well with the key variances identified in Figure 5.9.

5.6. Analysis of the Social System

The objective of this step is to identify the main characteristics of the existing social system, in order to determine the main elements

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1		1																				
2	MAKE APPOINTMENT		2	●																		
3	DELIVER CAR			3	●																	
4	VERIFY APPOINTMENT		○		4	●																
5	DESCRIBE SYMPTOMS					5	●															
6	DIAGNOSE PROBLEM						6	●														
7	ESTIMATE COST							7	●													
8	WORK APPROVAL								8	●								○				
9	ASSIGNMENT									9	●											
10	CHECK PARTS										10	●										
11	PARTS AVAILABLE											11	●					○				
12	INSTALLATION/REPAIR												12	●								
13	INSTALLATION/REPAIR CORRECT												○	13	●							
14	SUCCESSFUL REPAIR						○								14	●						
15	PAYMENT															15	●					
16	PICKUP CAR																16	●				
17	ENVIRONMENT																	17				
18																			18			
19																				19		
20																					20	
21																						21

FIGURE 5.10. ENLARGEMENT OF TASK-TASK SUBMATRIX SHOWING PRECEDENCE RELATIONSHIPS BETWEEN TASK PAIRS

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1		1																				
2	MAKE APPOINTMENT		2																			
3	DELIVER CAR		●	3																		
4	VERIFY APPOINTMENT			●	4																	
5	DESCRIBE SYMPTOMS					5																
6	DIAGNOSE PROBLEM					●	6															
7	ESTIMATE COST					●	●	7														
8	WORK APPROVAL							●	8													
9	ASSIGNMENT					●	●			9												
10	CHECK PARTS										10											
11	PARTS AVAILABLE											11										
12	INSTALLATION/REPAIR					●	●			●			12									
13	INSTALLATION/REPAIR CORRECT													13								
14	SUCCESSFUL REPAIR					●	●			●					14							
15	PAYMENT														●	15						
16	PICKUP CAR														●		16					
17	ENVIRONMENT																	17				
18																			18			
19																				19		
20																					20	
21																						21

FIGURE 5.11. IDENTIFICATION OF KEY TASKS

of the organizational and process control mechanisms. This step seeks to identify such features as the ancillary activities, including those tasks not directly involved in production, such as process control and product quality control; spatial and temporal relationships between the various elements of the production system (e.g., distance or physical barriers between workers); worker mobility, i.e., the extent to which workers share a knowledge of each other's roles; the payment system; the extent to which roles meet the psychological needs of the workers assigned to them; and the areas of maloperation of the entire system. Representative features of the automobile repair facility are shown in Figure 5.12 through 5.16.

The basic elements of any social system are the members of it. In the example, the members are the individuals who are workers at the repair facility. Figure 5.12, in the shaded area, shows these individuals by name. Figure 5.13, in the shaded area, shows the roles which are played at the repair facility. These roles correspond to job titles, and would normally have a particular set of duties, or functions, associated with each. Neither Figure 5.12 nor 5.13 indicates any relationship between individual and role, nor between role title and functions.

The shaded portion of Figure 5.14 shows the assignment of individuals to roles. Jenner, for instance, is assigned the role of Service Manager, as indicated by the dot in row 13 (Jenner), column 18 (Service Manager). While in this case, persons and roles are matched 1 to 1, in general, one person can play multiple roles. Situations might arise, too, where several individuals can be assigned to a single role class.

Figure 5.15, in the shaded area, shows the assignment of roles to conceptual resources, here, the organizational groupings. The Service

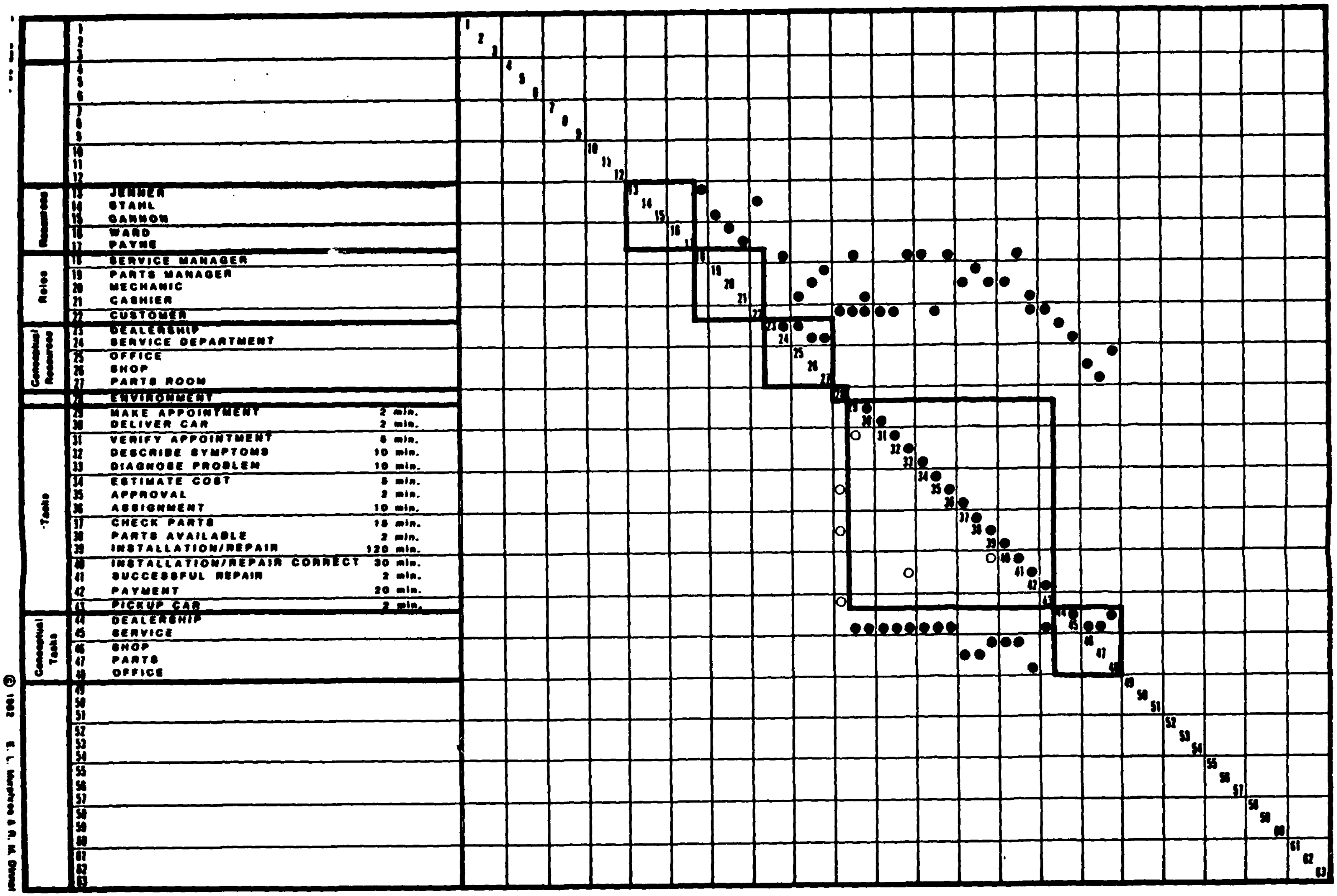

FIGURE 5.12. IDENTIFICATION OF THE BASIC RESOURCES

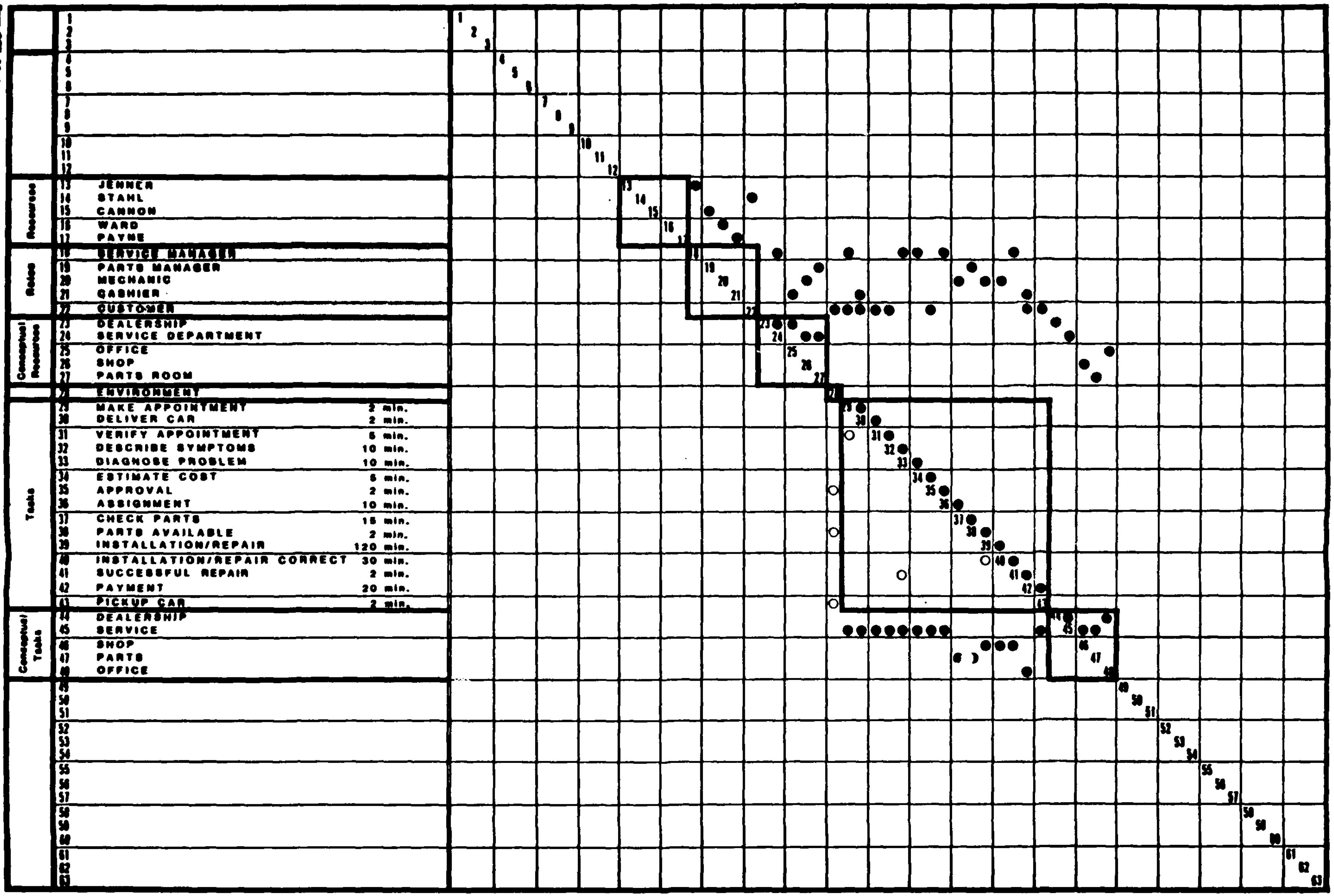

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FIGURE 5.13. IDENTIFICATION OF THE ROLES

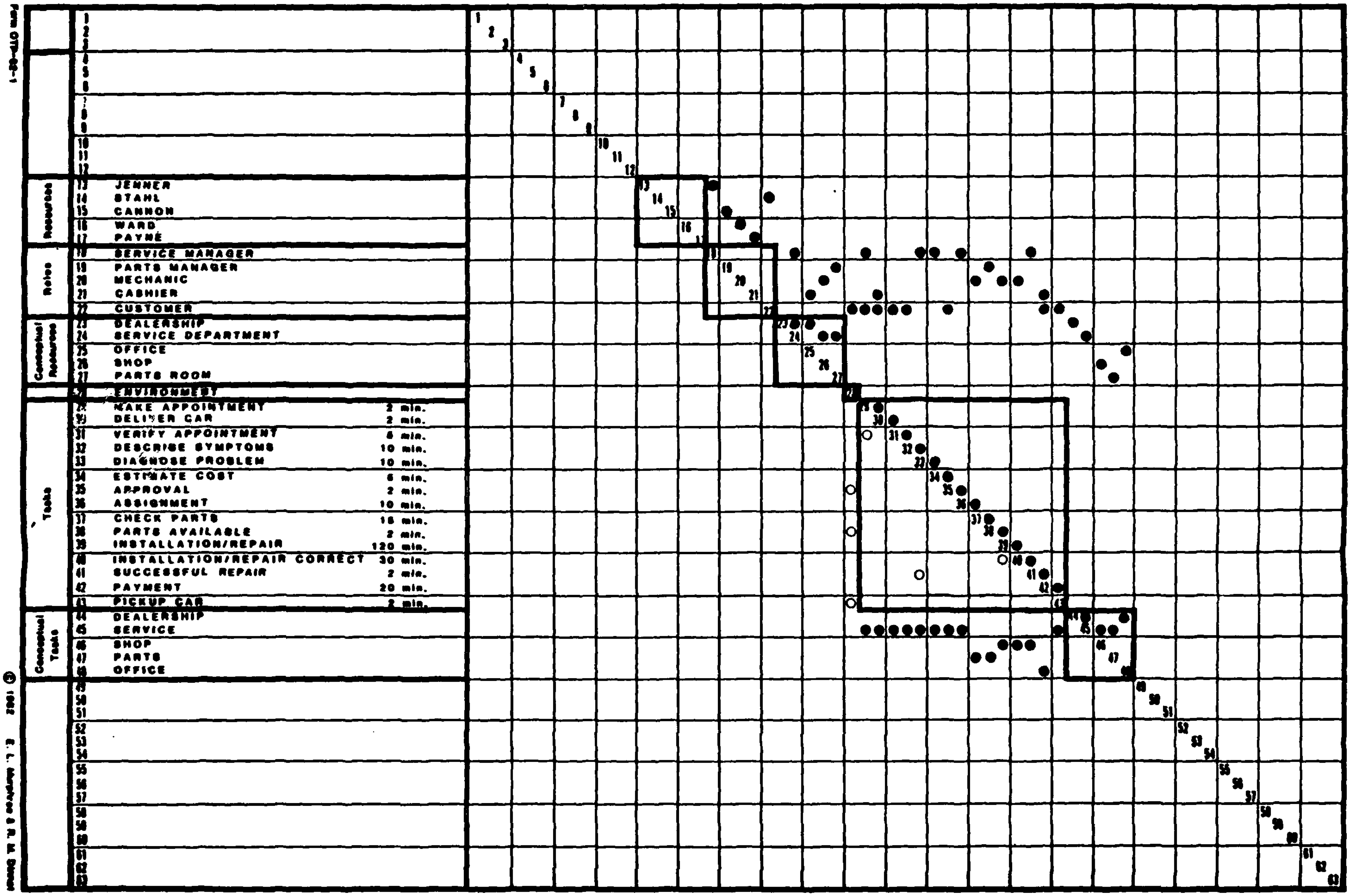

FIGURE 5.14. ASSIGNMENT OF INDIVIDUALS TO ROLES

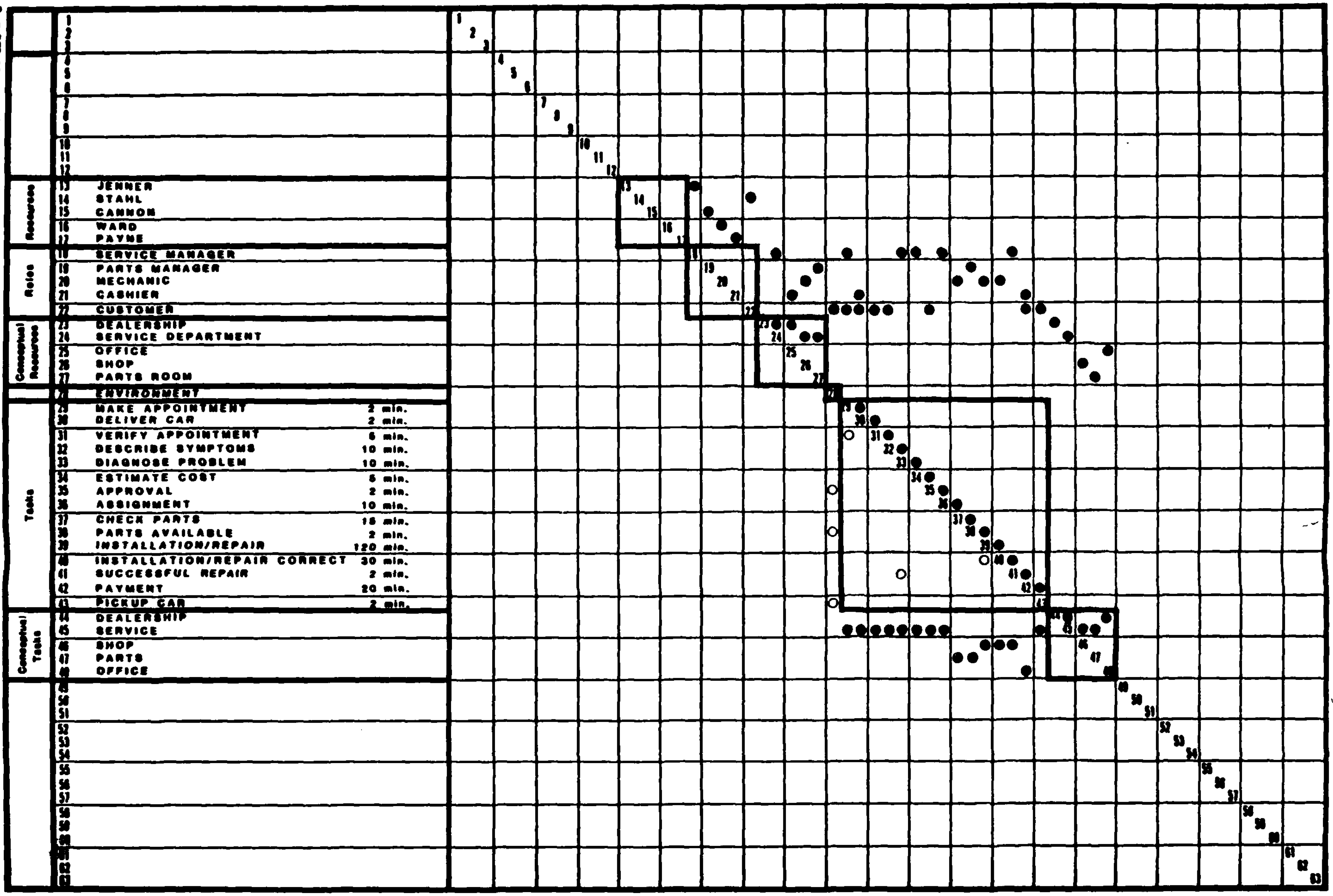

FIGURE 5.15. ASSIGNMENT OF ROLES TO CONCEPTUAL RESOURCES

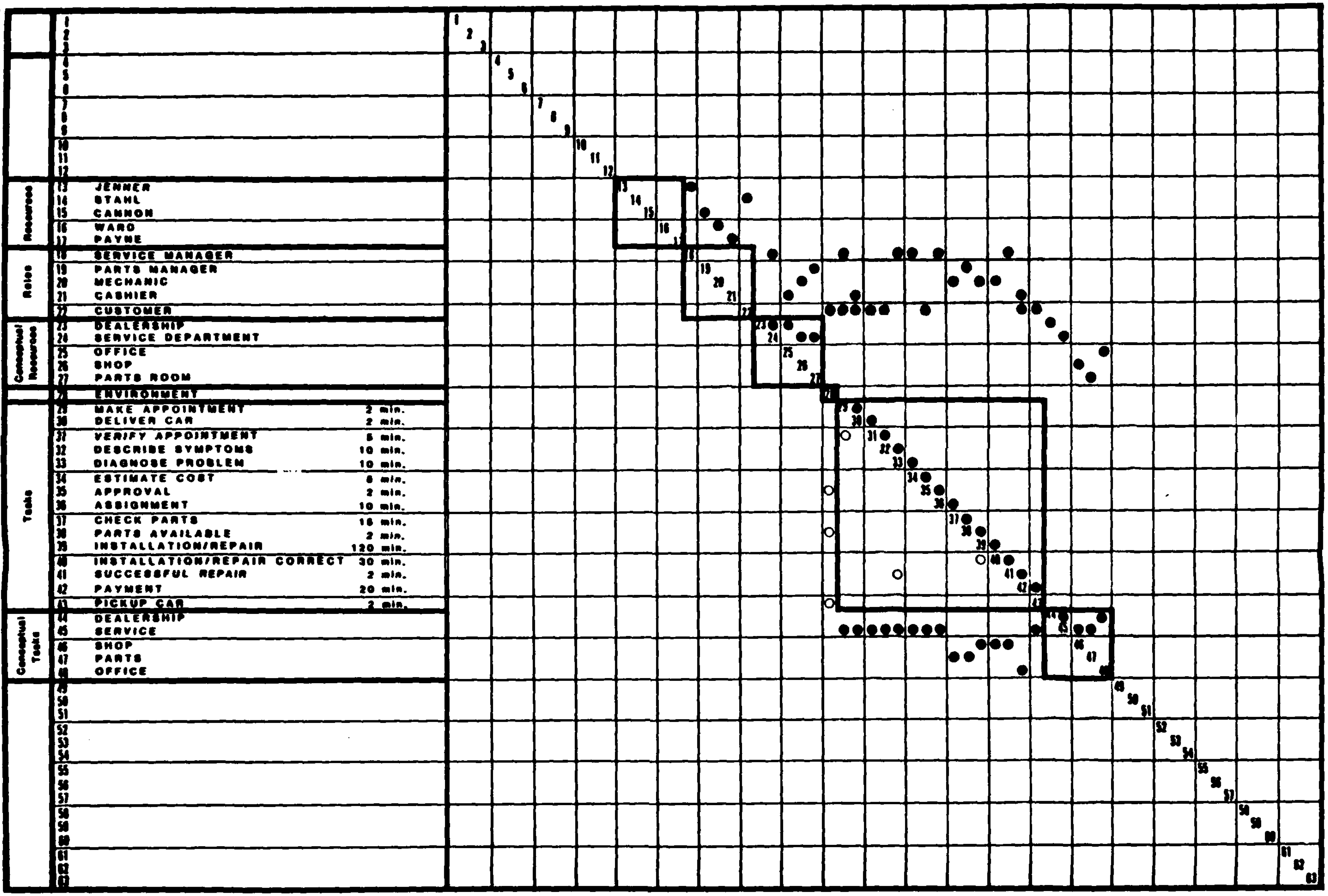

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FIGURE 5.16. ASSIGNMENT OF ROLES TO TASKS

Manager (independently of the individual assigned that role) is assigned to the Service Department (the dot at line 18, row 24); the Parts Manager to the Parts Room; and the Customer to the Environment. The shaded portion of Figure 5.16 shows the assignment of Roles to Tasks. More than one role (resource) may be required to accomplish a single task; for example, both Customer (line 22) and Service Manager (line 18) are required to do the task at line 29, "Make Appointment," as indicated by the dots at line 22, row 29 and at line 18, row 29. Only the Service Manager is required for a Cost Estimate (line 34), and only the Mechanic checks for parts (line 37).

The foregoing are but a few of the enormous number of relationship patterns that make up a dynamic social system. This sampling should serve to make it clear to the reader that if a relationship can be conceptualized, it can be modeled.

Emery and Trist's Step 5, People's Perceptions of Their Roles, are not separately treated here, since we consider (indeed, as Emery and Trist do) this to be a part of the social system.

5.7. Subsystems

The Shop is the site of the production system of the repair facility. Clearly, the Office and the Parts Room are the sites of part of the Supply and User Subsystems, but the detail of resolution does not allow us to go into more depth in detailing the micro-tasks and micro-roles that are involved in operating these subsystems. Likewise, the Maintenance Subsystem (building operation, maintenance, and repair; tool and equipment maintenance and repair; psychological and economic provisions for the members of the organization, such as vacations, coffee breaks, and the like) is not

visible at all from the data we have about the organization. No information is available, either, about the work environment (the physical space, the psychological ambience) or the development plans of the organization.

To the extent that these subsystems can be defined in terms of the entities (resources, tasks, roles, etc.) already identified or further identified, and relationships, then the subsystems can be included in the model. To be sure, an in-depth analysis of a real organization would likely include analyses of the important subsystems, in particular the control subsystem.

5.8. Proposals for Change

Figures 5.3 through 5.16 portray the Car Repair Facility as it exists. Any proposal for change can be expressed in the same format. For example, Figure 5.17 suggests three changes:

1. Stahl and Cannon swap jobs (roles).
2. The Service Manager as well as the Cashier and the Customer are required to "Deliver Car."
3. The Mechanic and the Service Manager jointly "Diagnose Problem."

These proposals for change are of limited scope, and as a result, they may be noted on the matrix rather easily. Many proposals, however simple they may appear at first glance, can cause a "rippling" effect throughout the entire matrix. Such organizational changes as involve the movement of tasks to new organizational groups, or the changing of the organizational structure can involve myriad changes in the matrix (and, of course, the real organization) to maintain consistency.

As every organizational man or woman knows, its not easy to reorganize.

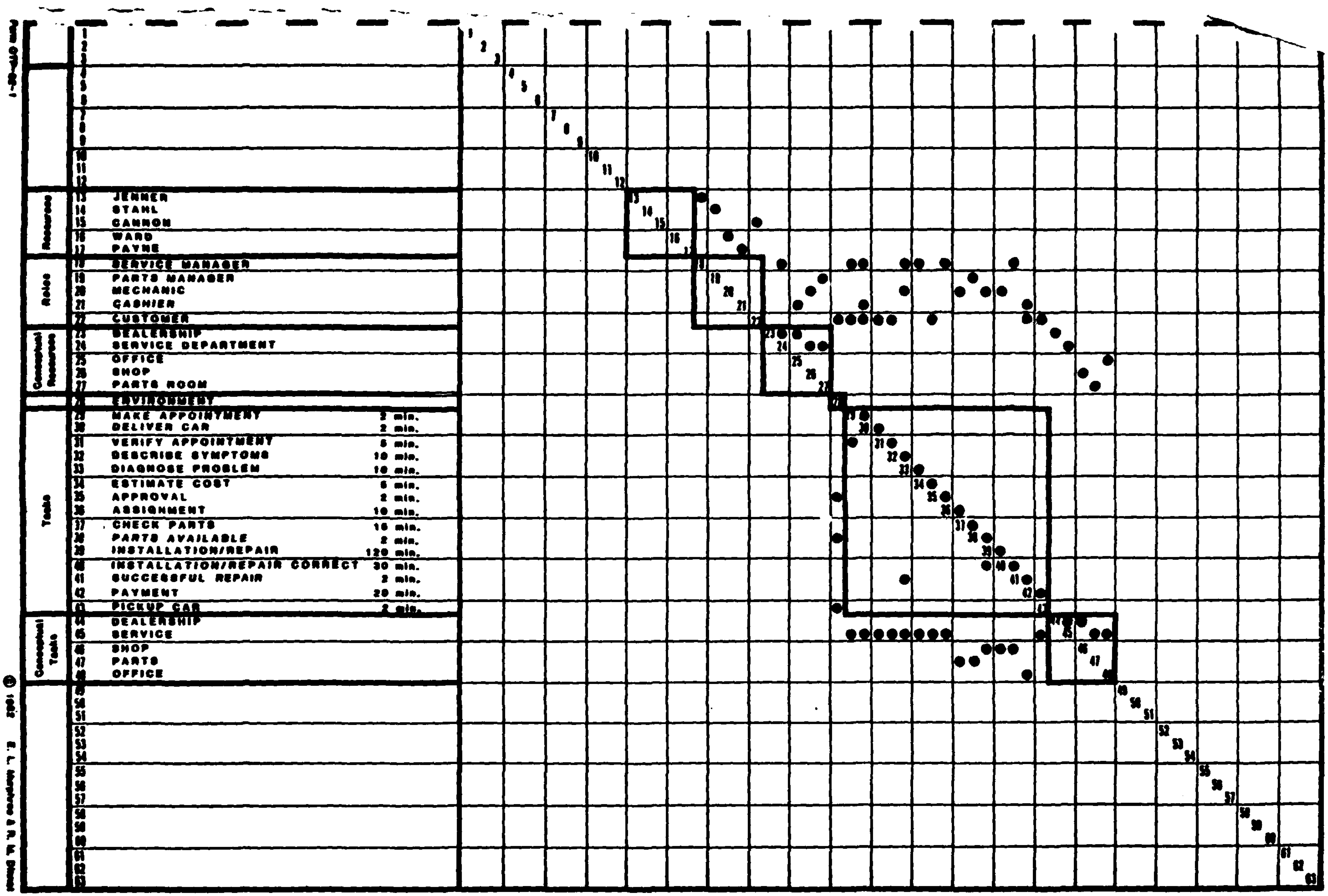

FIGURE 5.17. PROPOSAL FOR CHANGES TO THE ORIGINAL ORGANIZATION

6. Conclusions

There is no conceptual antagonism between the two models; indeed, it appears that each can be expressed in terms of the other. This is not, however, to say that they are identical, nor even equivalent. The D-M model is analogous to a tool for the study of anatomy, while the S-T model supports and guides a therapeutic intervention, in the manner of a surgeon. That the surgeon has a smattering of anatomy lends comfort to the patient. There is, then, good cause for the hope that the two approaches can be synergistically coupled, to the gain of all.

7. Recommendations

1. Adapt socio-technical interview techniques to gather relational and object data for Dinnat-Murphree model construction.
2. Develop techniques for organizational diagnosis with the Dinnat-Murphree model, followed by intervention by socio-technical methodology.

8. Appendix: References

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9. Appendix: Biographies

E. LILE MURPHREE, JR. is a graduate of the University of Mississippi (BSCE, MA in Mathematics), the Massachusetts Institute of Technology (SM in Civil Engineering) and the University of Illinois at Urbana-Champaign (Ph.D. in Civil Engineering Systems). He has held faculty appointments in Mathematics, Civil Engineering, Industrial Engineering, and Architecture. A Division Chief at the U. S. Army Construction Engineering Research Laboratory from 1969 to 1975, he is now President of Sage Systems Corporation, Urbana, IL, and Visiting Research Professor of Architecture, University of Illinois, Urbana-Champaign.

ROBERT M. DINNAT is a graduate of the Louisiana State University (BFA), the Georgia Institute of Technology (Bachelor of Architecture, MS and Ph.D. in Civil Engineering) and the University of Illinois at Urbana-Champaign, MBA). He has held faculty positions in Civil Engineering and Architecture. From 1970 to 1979, he was a Division Chief at the U. S. Army Construction Engineering Research Laboratory; since 1979, he has been Associate Technical Director there. Dr. Dinnat is also Adjunct Professor of Architecture, University of Illinois, Urbana-Champaign. A full-time federal employee, Dr. Dinnat contributed time outside of his normal working hours to the project reported here.

RICHARD MATTHEWS is a graduate of the University of Kansas (Bachelor of Environmental Design, with Highest Distinction; Bachelor of Architectural Engineering, with Distinction); and the University of Illinois, Urbana-Champaign (M. Arch., MBA). In 1975, The Ewart Scholarship allowed Mr. Matthews to study architecture for a year at Heriot-Watts University, Edinburgh, Scotland. He has been a designer with Design Associates, Amarillo, TX, and has held research positions at the University of Kansas and the National Bureau of Standards. A private pilot and a violinist, he has also had experience in building and programming digital computers.

NANCY S. CARREON is a graduate of the University of Illinois, Urbana-Champaign (Bachelor in Architectural Studies) and is currently enrolled at the University of Illinois, Urbana-Champaign, in the combined M. Architecture and M. Business Administration program. She has held two positions with the Commonwealth Edison Company, Chicago, Illinois: One as a marketing technician doing research in HVAC and a second as one of four staff architects in charge of the company buildings. She has also been a designer/draftsman for Alfred Engineering, Inc., Chicago, Illinois. A member of student organizations, she is actively involved in the Construction Specifications Institute and is initiating a student chapter of ASHRAE.

BERT W. ELLIOTT is a graduate of Miami University, Oxford, Ohio (Bachelor of Environmental Design) and is currently enrolled at the University of Illinois, Urbana-Champaign (M. Arch., MBA). He has recently held a research position with Owens-Corning Fiberglas Corp., exploring the energy performance of buildings. In addition, Mr. Elliott has been employed with The Collaborative Inc., a Toledo, Ohio, design firm.

M. WAYNE HARLESS is a graduate of the University of Illinois at Urbana-Champaign (Bachelor of Science in Architectural Studies with honors), and will, in May, 1982, graduate again from the University of Illinois (M. Arch., MBA). He has been a designer with Jackson and Associates in Champaign and is a registered Real Estate Broker in the state of Illinois. Mr. Harless has been a member of Gargoyle, an architectural honor society, since 1978. He enjoys golf and tennis.